SCIENCE DISCOVERED ETHER WAVES IN 1865

Inventor of the Audion Traces Development of Wireless and Marks the Important Milestones of Progress —1907 Noted as a Turning Point

By DR. LEE DE FOREST.

RADIO, in reality, is more than 60 years old. Broadcasting, from which hundreds of thousands nightly derive pleasure and entertainment, descended directly from the theoretical studies and mathematical conclusions of Professor J. C. Maxwell, who in 1865 as a result of his experiments and research, published his conclusion that heat and visible light consisted of electrical vibrations of the ether.

In the year 1887, Heinrich R. Hertz, a German physicist, student of higher mathematics and profound experimenter in electrical phenomena, in an effort to prove or disprove Maxwell's theories, carried the work on further than had Maxwell himself. He succeeded in showing by means of exact experiments that the ether of space would transmit these so-called electro-magnetic waves. Hertz in these experiments found that when an electrical spark leaped the gap between the terminals of a proper spark-gap, electrical oscillations took place in these terminals which set up waves of an electro-magnetic character in the surrounding ether and that these vibrations would in turn affect any adjacent conductor in that field. If that conductor were formed in such shape as that of a circle of wire in which a small gap had been left, a tiny stream of sparks would jump this second gap while the induction coil was in operation, under certain conditions. In the case of Hertz's experiments the ring, or resonator, formed the detector and it was found that these waves had the power of traversing space for quite a distance, even though intervening partitions were placed between the source and the "resonator." This experiment was made the source of a series of most profound mathematical essays and conclusions, most of which were presented before the Berlin Academy of Science during the years 1857-1888.

Branly Invents Coherer.

The next important step connecting the former two with our present-day radio was in the year 1890, when Professor Branly discovered that a short glass tube loosely filled with fine metal filings and normally a very poor conductor of electrical current, due to its high resistance, could be made a very good conductor under the stress of the "Hertzian" waves. Branly named his device a coherer, because of the fact that these waves caused the filings to cling together and form a cohesive conductor or path for electrical current. His method was a surer and more sensitive way of detecting these waves than was the resonator of Hertz.

Following upon this early work of Branly the next available link we note in the chain connecting these early experiments with our present-day radio was in the year 1895, when Signor Marconi, utilizing the derivation of the Branly-Popoff coherer, connected to a wire running into the earth on one end and into the air in the other, found that he could materially increase the distance between the spark discharge and the indicator, provided that a similar aerial and earth arrangement was employed in the spark coil installation. Experiments proved that the higher these two wires, or the larger the surface of the two metal plates which were generally used in those days, and the stronger the power of the spark, the greater the distance that could be covered between the two. Further experimentation along similar lines showed that actual Morse signals of an intelligible sort could be accomplished by reading the tickings of the de-coherer buzzer.

During the years intervening up until 1898 Marconi improved his antenna, or gathering system, until during that year he succeeded in transmitting a series of dashes over the then unheard-of distance of fifteen miles. By this time the experiments in this field had attracted wide attention and others entered the field, such as Sir Oliver Lodge, Slaby, Arco and Braun in Germany.

During the period beginning with 1900 I became interested in the commercial possibilities of wireless telegraphy and entered the field. By the time 1901 had arrived several important advances had been made, chief among which was the use of a self-resoling coherer and the telephone receiver which this made possible.

The Electrolytic Detector.

The following year Professor Fessenden brought out another type of self-restoring coherer, an electrolytic detector, consisting of a small platinum wire encased in glass the tip of which with a small section of the wire protruding and in contact with a weak solution of nitric acid, across the terminals of which there was placed a potential. This formed a reliable rectifier and permitted more general use of head phones than had heretofore been possible. The use of coherers and relays with local batteries had rendered impractical the use of head phones. Marconi, working along similar lines, those of rendering the reading of signals better and easier, then invented the magnetic detector while Professor Braun in seeking to adopt the coherer for use with ear phones laid the basis for the later-day crystal detector.

It was early during this hectic period that I made the initial discovery which was later to result in the first "audion." I had upon several occasions noted a most novel phenomenon in the flickering of Welsbach gas lights when wireless transmitting was going on in the laboratory, and, though serious experimenting was later done along this line, little was really accomplished at that time. The ground work was accomplished, however, when I discovered that the gaseous ions in flames could be made to detect the weak currents, even though unreliably.

Wireless had by 1904 reached no uncertain point of perfection and such stations as Block Island, Point Judith, Coney Island and numerous other places had been erected. The American Cup races of 1903 were more or less successfully reported from press boats to a shore station and thence relayed by means of land telephone. The St. Louis Fair offered to the few companies engaged in commercial work a rare opportunity for displaying the progress attained. The wireless stations installed were among the chief centres of interest of the entire exposition.

The receivers of that period were fearsome articles, consisting of large coils with multitudinous brass switches and probably an unlovely looking variable condenser of about the dimensions of the present day "giant storage battery." The transmitters were even more fearsome, consisting of huge transformers generally as tall as an average man and gave a spark two or three inches across which could be heard for half a mile or more. In England such transmitters were operated by means of a key with a "pump" handle nearly a foot long, the contacts of which generally sparked and arced almost as badly as did the gap itself.

Poulson Used an Arc.

During the year 1903 the Danish inventor Poulson designed an arc transmitter capable of generating undamped waves and succeeded in covering greater distances by means of it than would an ordinary spark transmitter of twice the power.

On Jan. 18, 1907, I was granted the first patent on the "audion" or first practical three electrode vacuum tube. This was the outcome of over five years of experimentation and research, going by difficult stages through these years I arrived at an evacuated globe in which were sealed a filament, a square of platinum for a plate, and between these a nickel grid fashioned on a jeweler's vise with a pair of pliers.

Incidentally it might be of interest to mention that one of the first evacuated tubes that was experimented with utilized a piece of sodium to produce the necessary flow between the elements. This was discarded about 1903 on account of practical difficulties in maintaining a means of heating the sodium and also in view of the fact that the operation of the tube containing sodium was "tricky and entirely unreliable."

Because of the rather vague understanding of this new device, it was not appreciated at once, nor until it had been demonstrated that it was a more sensitive and reliable agent for the rectification of signals than either the electrolytic or the newly popular crystal combination detectors.

Turning Point in Radio.

The years 1906-8 might be called the real turning point of radio because from that time on there was a certain positiveness about the performance of wireless which overcame finally and for all, assertions that it was only the dream of visionary scientists. It is also notable that during these years the thoughts of wireless inventors turned to a yet more difficult field, that of radio telephony.

Further than this, the shipping world had now definitely recognized the possibilities of radio, and many of the larger steamships boasted a "wireless telegraph receiving and transmitting station aboard."

By the time 1907 had arrived a regular press dispatch service between Europe and America had been inaugurated and was occasionally in allegedly "twenty-four-hour service."

I had made numerous experiments in radio telephone work through the year 1907 which promised much for the future. This work was done by modulating the wave-train of a small transmitting arc, and the work was moderately successful. It is a notable fact that at this time the amateur experimenter, the man who merely played with radio, now entered the field, and a small number of men scattered the country over formed the nucleus of what later was to become one of the largest independent non-commercial amateur fads—"the hams."

Between the years 1908-9 most all of the first-class ships had been equipped with radio apparatus.

It was also at this time that the first practical demonstration of wireless telephony was made in Europe. A distance of over 300 miles was actually covered after over three months experimenting around Paris, using the Eiffel Tower as a support for our antennae. The transmission program on this occasion consisted of replaying constantly a few talking machine records throughout the greater part of an entire night and then waiting the next day to hear from the various French wireless stations as to how Tower had been heard and how good was the reception.

During 1910-11-12 the general use of radio for practically all classes of ships had become possible.

During 1913 the first general use by private individuals of vacuum tubes even on a limited scale was noted. Even at that time the crystal detector was still in use and was far more used by the amateurs than was the vacuum tube.

In 1914 the World War broke out, and radio immediately came to the front as the most reliable means of communication.

During the second year of the war, 1915, the first long-distance radio telephone transmission was accomplished from Arlington, Washington, D. C. A special transmitter consisting of 150 oscillions or high-power "audions" for oscillating purposes was used and one-way communication was established to Paris and Honolulu. This experiment demonstrated to radio engineers without a doubt that the three-electrode oscillator could be used for power telephony much better than the arc type of transmitter used in telegraphy. It has been estimated (I can't say how accurately) that these experiments cost, due to the fragile nature of the installation and the special generators used, over $1,000 per hour of actual operation, which, considering the time used for the actual broadcasting of the message, represented a cost of several dollars per word uttered.

The messages, however, simultaneously heard in both Honolulu and Paris, broke all records for distance, and proved that in the "audion" lay the solution to the successful transmission of speech over long distances.

During the remainder of the war, and until 1918, radio changed rather rapidly, as events coming up directly after the war proved.

After the war there was the usual lull in things necessary to readjustment.

Nineteen hundred and twenty saw the first renewed attempt to broadcast music and entertainment as we know it today.

At that time there were two circuits in general available to the public, or rather two circuits whose simplicity allowed of their common adoption—the crystal set and the one-tube regenerative set. Naturally, the receivers were home-made, because, with the possible exception of five manufacturers who were making apparatus for the amateur field previous to the war, and who continued after the war was over, no one in the field was in the least prepared for the work of furnishing apparatus for broadcast receptions. The new radio had appeared too suddenly—no previous warning as to its popularity was given.